TECHNISCHE UNIVERSITÄT DRESDEN

IMS International Masonry Society

8IMC_227

Use of geo-electrical measurements as NDT for masonry walls

SCHUEREMANS L.

July 5th, 2010 at Hilton Hotel

Introduction

Goal: quantifying heterogeneity of masonry.

- Holes and cavities: stress concentrations;
- 3-leaf masonry: benefit from good bond in between external parament and core infill masonry;

How:

- Measuring electric resistivity distribution – difference in electric resistivity in between masonry (brick/stone/mortar) and voids/holes/cracks/cavities substantial

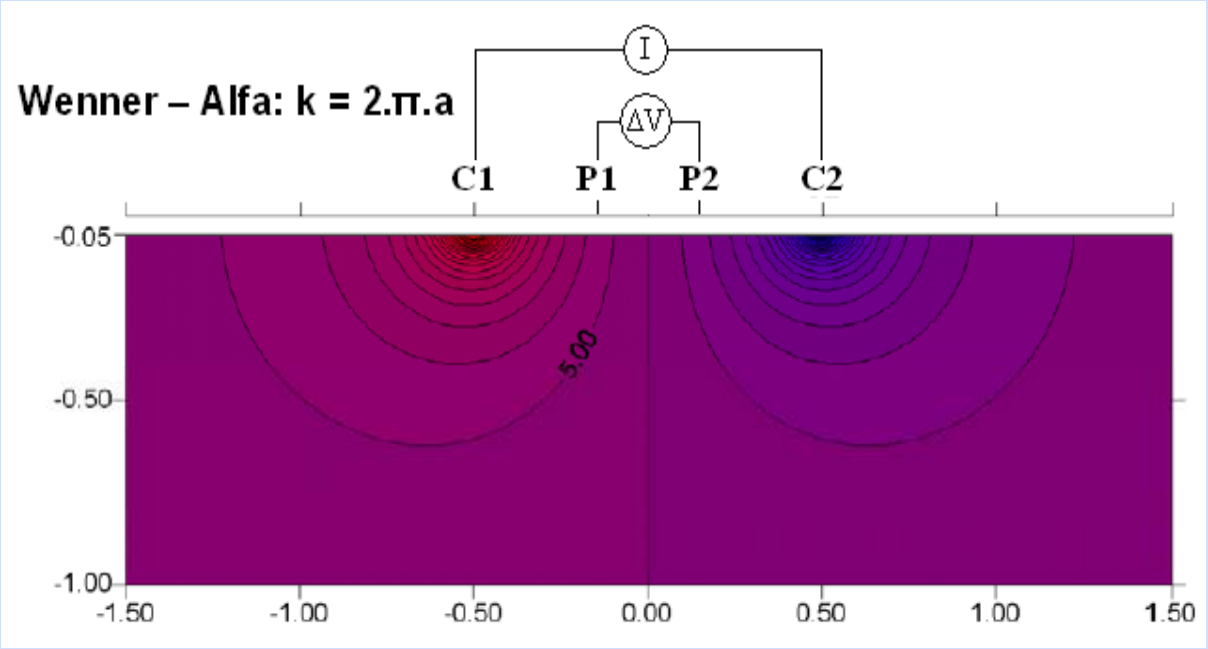
Basics of geo-electrical measurements

Measurement principle: Ohm's law

apparent resistivity value:

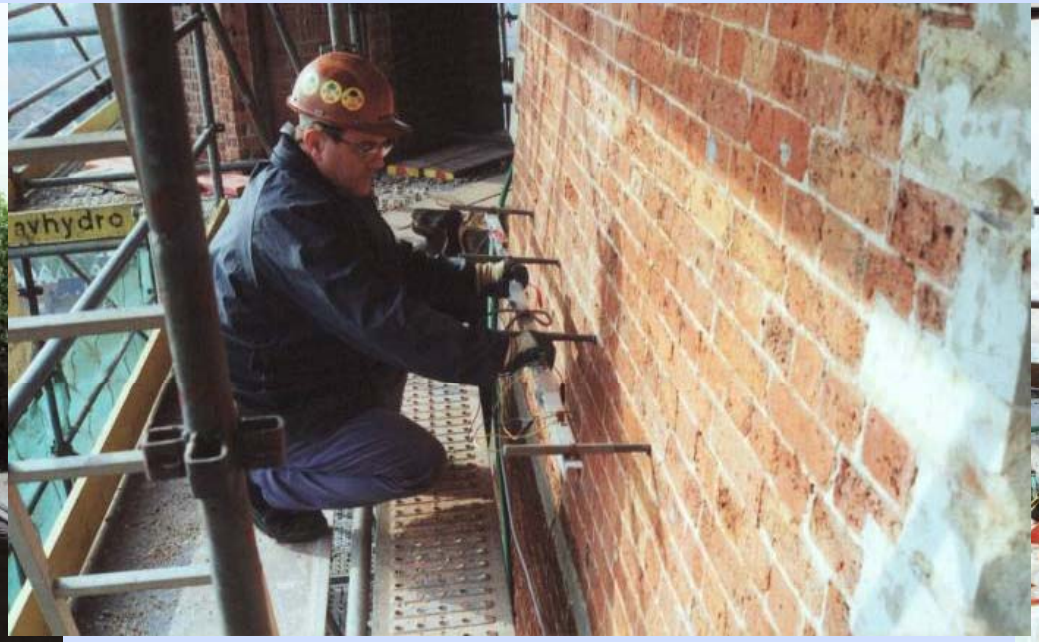
> "Resistivity that would be measured in case of a homogeneous material"

Reality: wall has a heterogeneous resistivity distribution.



Elder case studies – 2-2 Alfa-Wenner - 1993

Church of Our Lady, Brugge (B) and quay-wall of ‘s Hertogenbosch (Nl).



use of an Alfa-Wenner configuration, 2 current and 2 power electrodes,
cross-section is scanned at several positions,
resulting in an apparent resistivity map + additional destructive core drilling,
a qualitative impression on the homogeneity of the masonry could be obtained.
→Further local consolidation -grout injection- could be advised upon.

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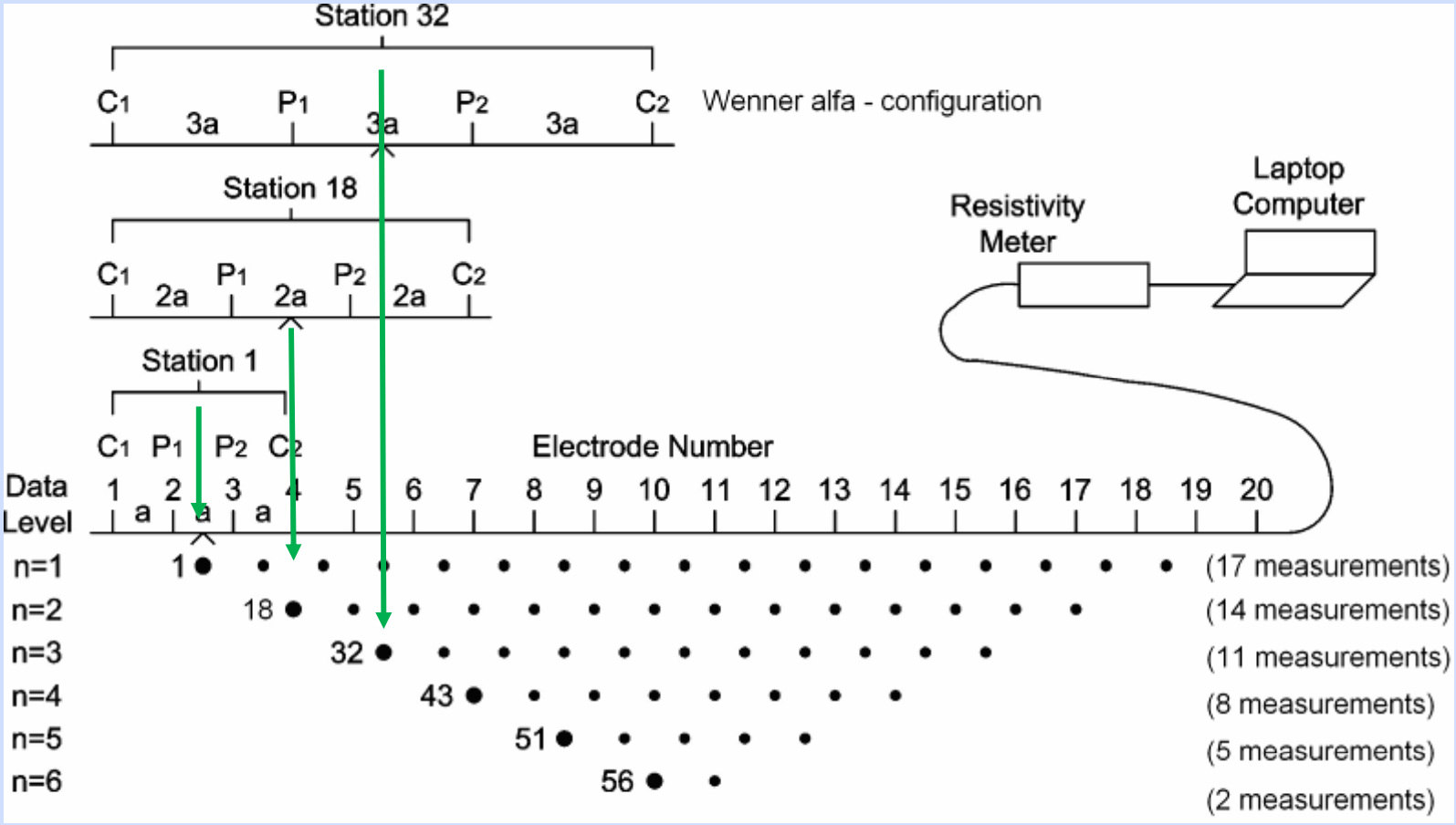
The measurements construct a pseudo-section, which is the graphical representation of the apparent resistivity values for a 2D-section of the masonry wall.



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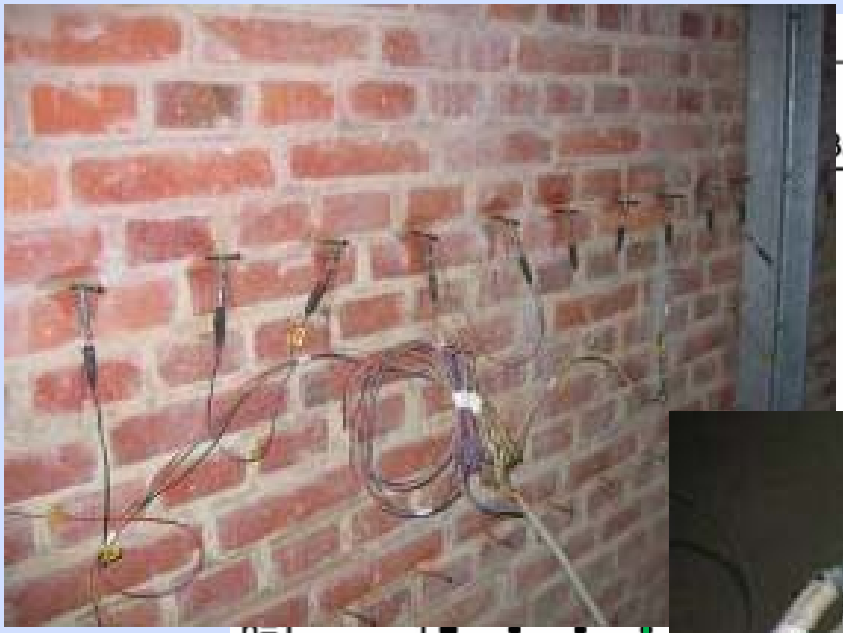
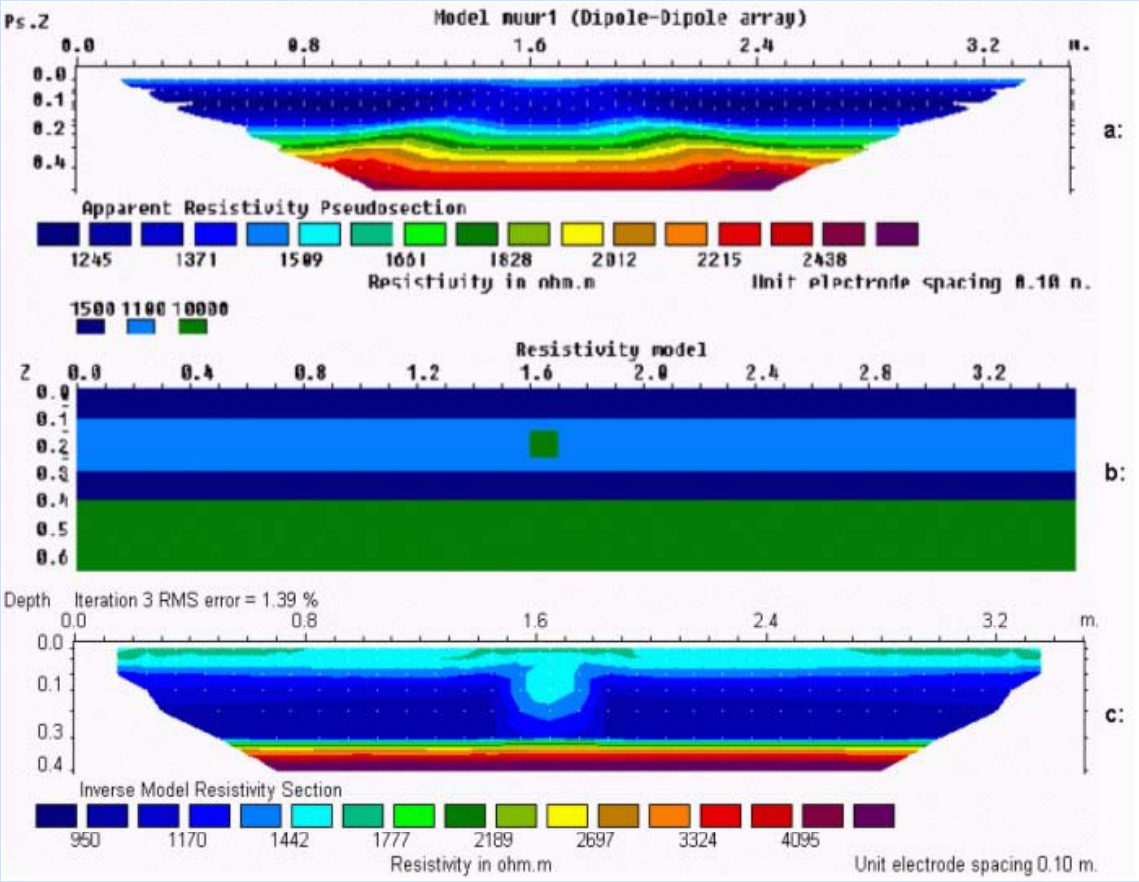


Basics of geo-electrical measurements

Inverse modeling enables to reproduce the resistivity distribution in the masonry structures that originates in the obtained pseudo-section.



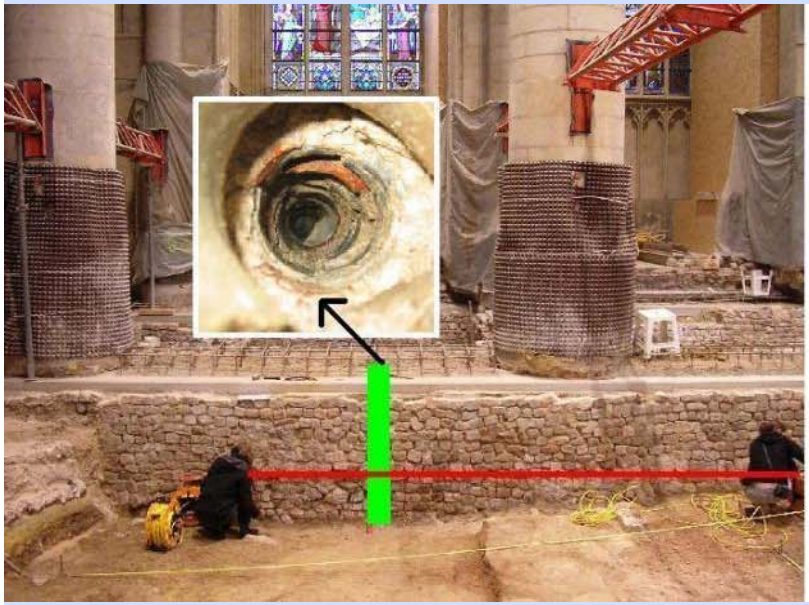
Case studies – first tomography

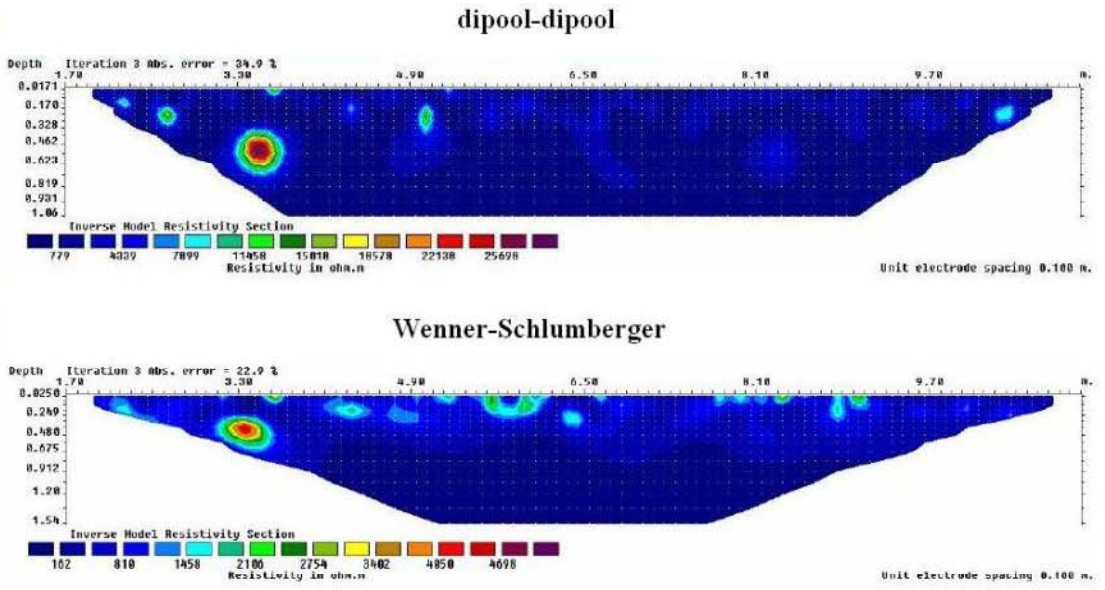
Basilica of Our Lady at Tongeren (B).

First application of pseudo-section technique originating from geophysics within the field of geo-electrical survey of soils.

A geo-electrical tomography was performed for controlling the efficacy of the injection under a representative column.

48 stainless steel nails, spacing 10 cm, are used as electrodes, placed on a survey line approximately spread out 1 meter under the column.

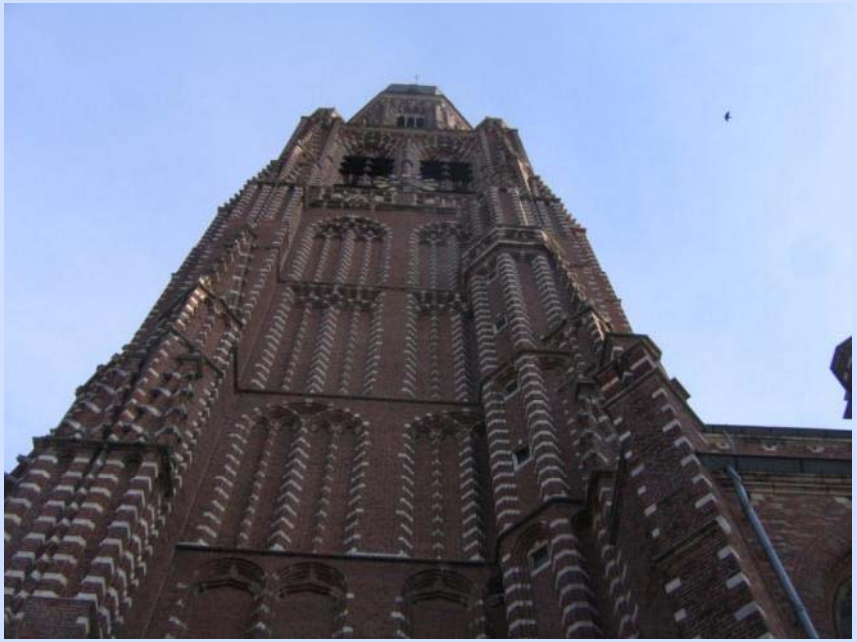




Case studies - tomographies

Bell tower of the Sint-Catharina church at Hoogstraten (B).

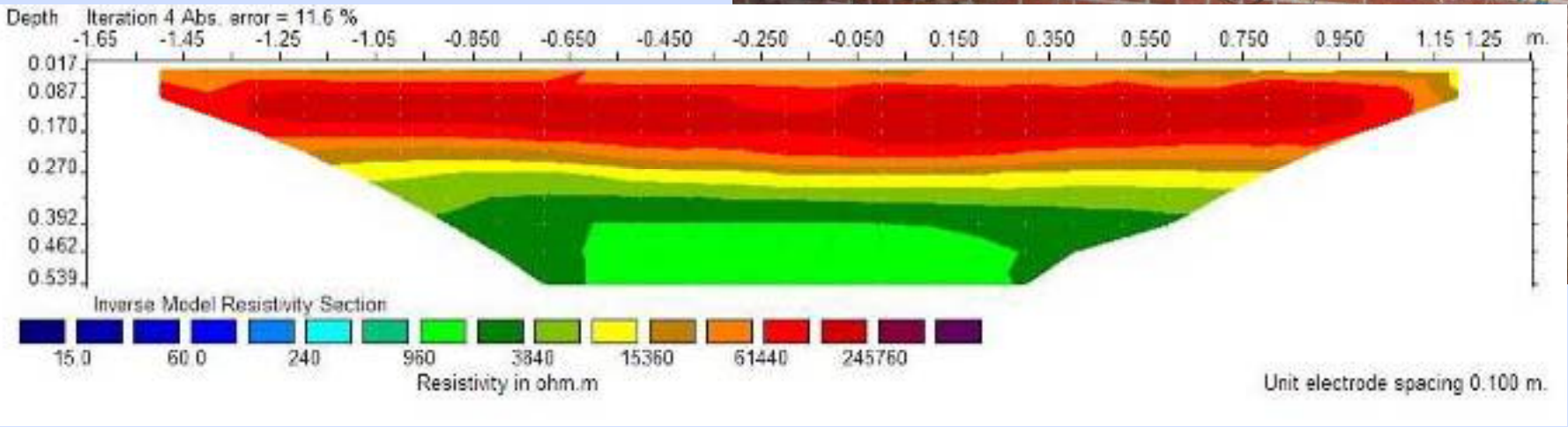
The bell tower of Sint-Catharina church at Hoogstraten has been restored after being damaged during the 2nd World War. To assess the overall quality of the masonry, at several heights a reference measurement was performed using geo-electrical measurements.



Case studies – tomographies

Bell tower of the Sint-Catharina church at Hoogstraten (B).

Clear stratification within the results: the solid masonry had a clear moisture profile as function of the depth of the masonry. The inner part of the masonry was dry because of the heating installation at that level, the outer part of the masonry was more humid caused by rain (west side of the tower).



Case studies – quality control of consolidation

The Castle of Beersel (B) and the windmill at Pendrecht (Nl).

- intended to judge the quality of grout-injections performed as means of consolidation of the masonry.
- the geo-electrical measurements are performed at two stages:
- STEP 1:reference measurement before injection works.
- STEP 2: the measurement campaign is repeated after consolidation of the masonry using grout injection.
- Since the geo-electrical measurements give a visual impression of the heterogeneity of the masonry, a comparison before and after injection could enable a qualitative judgment of the consolidation works performed

Case studies – quality control of consolidation

The Castle of Beersel (B) and the windmill at Pendrecht (Nl).

Monitoring of 150m² at 3 regions.

→ the areas in which a successful grout injection was obtained could easily be identified

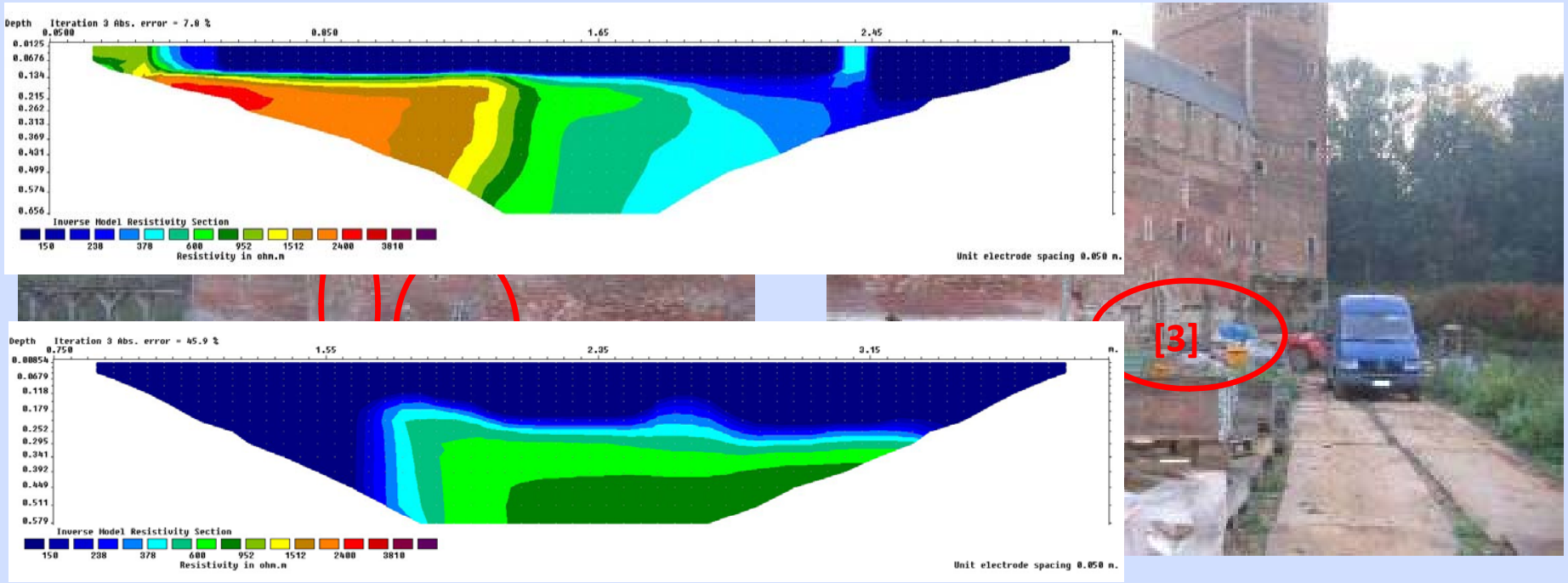
Case studies – quality control of consolidation

The Castle of Beersel (B) and the windmill at Pendrecht (Nl)

(+) Further investigation data:

- figures related to the volumes injected in certain areas;
- discussion with the contractor performing the injection.

→ the difficulties encountered during the injection were retraced



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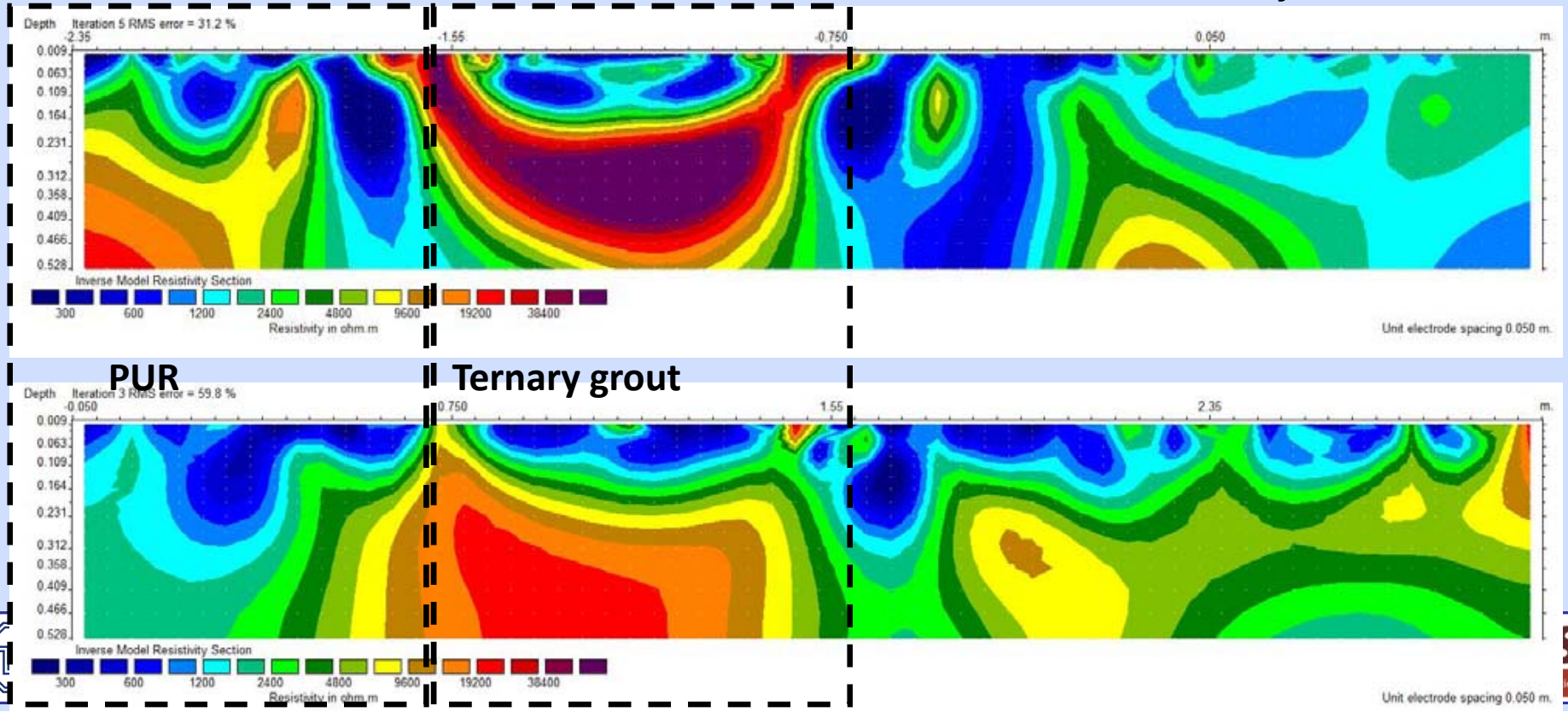
The Castle of Beersel (B) and the windmill at Pendrecht (Nl).

comparative study in between two injection products to improve the water tightness of the masonry wall (thickness: 30 cm)

Case studies – quality control of consolidation

The Castle of Beersel (B) and the windmill at Pendrecht (Nl).

- none of the materials was applied in optimal conditions (no change in homogeneity);
- the reference measurement: after a stormy night in June, the second measurement: after a sunny period half September. A clear difference is visible in the obtained resistivities, also in the areas without injection.



Cross-bore Hole Technique

Geo-electrical tomographies,have the disadvantage that the resolution decreases with the penetration depth of the measurements.

→ Measure from two sides:

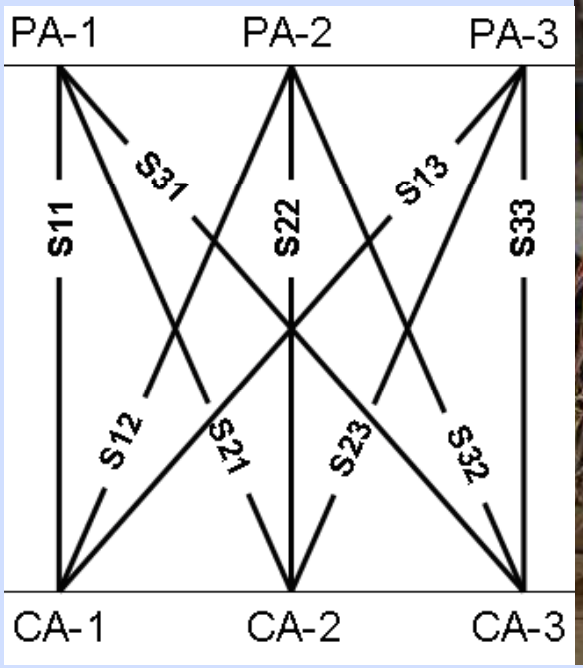
3*16 current electrodes: active side

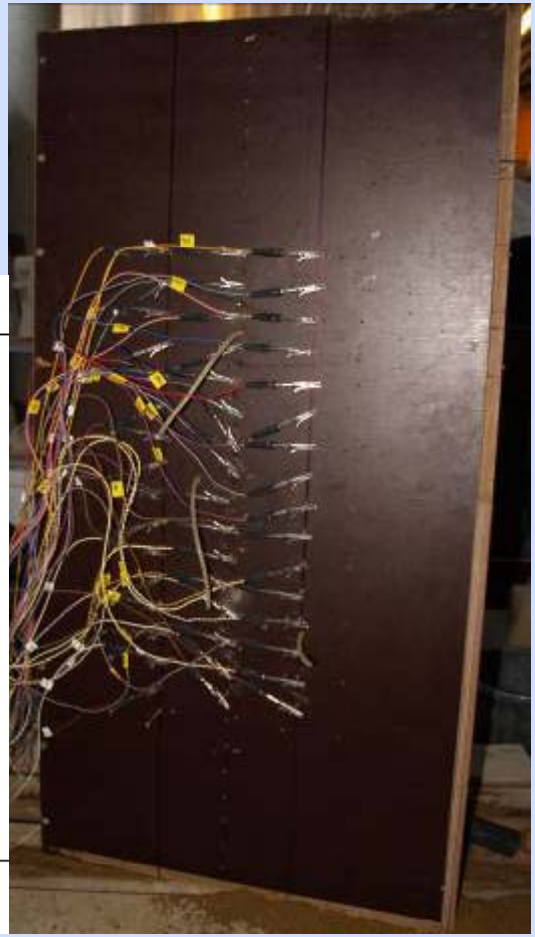
3*16 potential electrodes: passive side

3D-image build by combining

9 “2D”- cross-borehole images

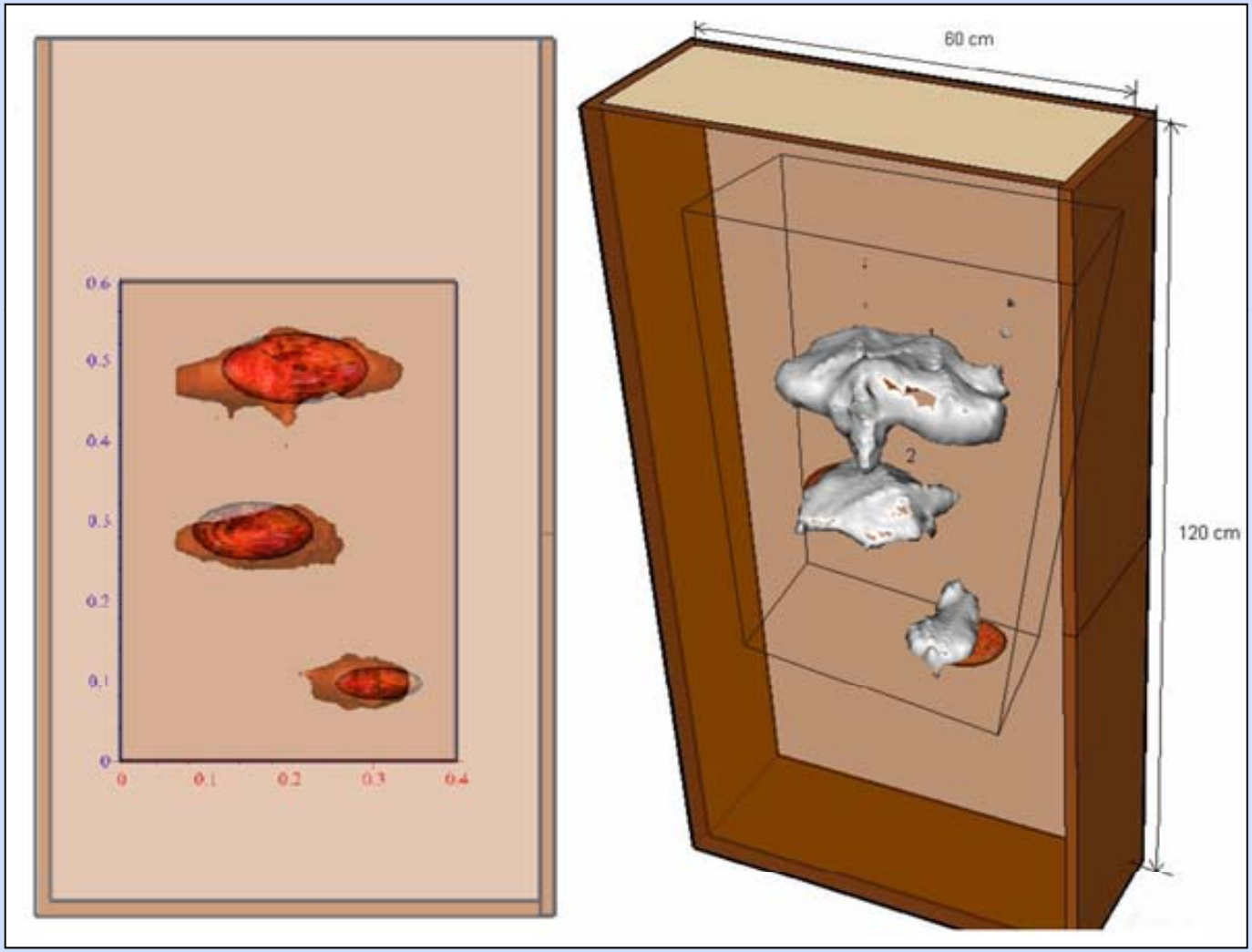
120 seconds





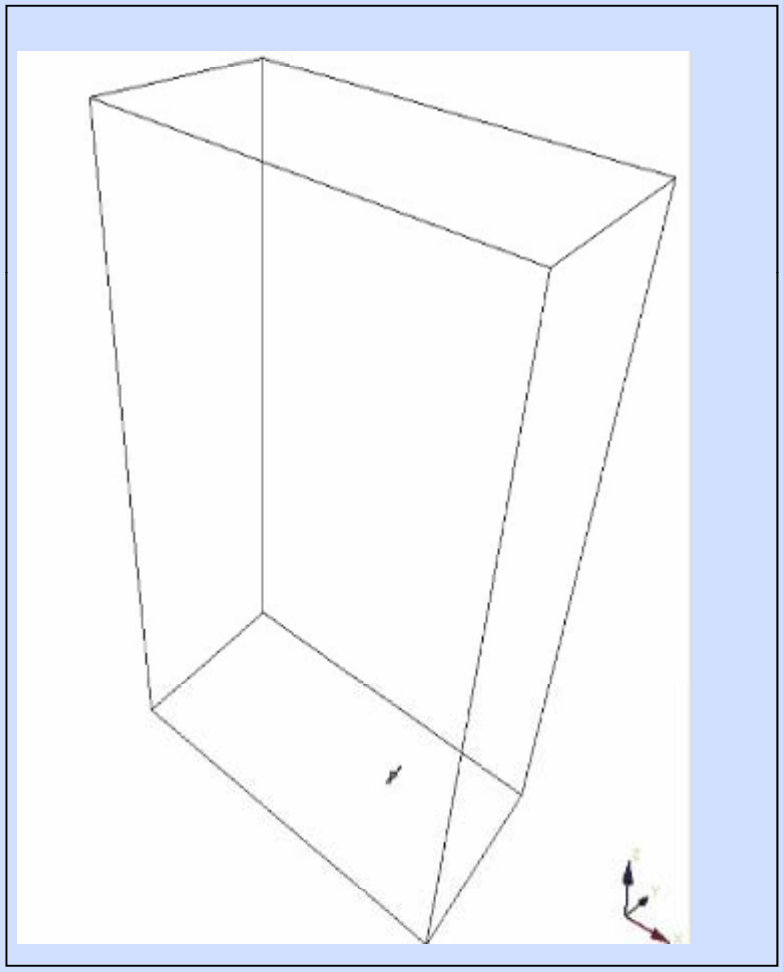
Cross-bore Hole Technique

Measurement during grout injection of cavities (tennis court gravel) in sand volume.



Cross-bore Hole Technique

Measurement during grout injection of cavities (tennis court gravel) in sand volume – aims at on-line monitoring of grout injections.



Conclusions

Starting from 1993 the technique of geo-electrical measurements evolved into a mature non-destructive technique (computational capacity, developments geo-physics, inverse modelling)

→ improved resistivity tomographies /cross-borehole on the one hand

→ measurement and processing of data of large areas in an acceptable time period on the other hand.

Side remarks remain:

- The electric resistivity is influenced by the **moisture content** and **moisture profile, salt concentration** and **salt profiles** within the masonry;
- It largely helps to correlate the information with the actual data from injection procedure. Therefore, data related to the injection procedure, grid used as well as volumes injected within each of the injection nozzles compared with the resistivity values obtained at these points give far more reliable conclusions.